

DUCT INSTALLATION AND SEALING STANDARDS

**Produced for: Pacific Gas & Electric Company
123 Mission Street
San Francisco, CA 94105
Telephone 415-973-7000**

**Prepared by: Dr. James E. O'Bannon
Richard Heath & Associates
310 Salem Street, Suite B
Chico, CA 95928
Telephone 530-898-1323**

All contents of this document are protected by copyright. No portion may be copied or duplicated in any format, printed or electronic, without the express written permission of Pacific Gas & Electric Company and Richard Heath & Associates.

**Published May 7, 1999
Revised September 15, 2000
© Pacific Gas & Electric Company
© Richard Heath & Associates**

All materials and workmanship in the Residential Contractor Program shall be in compliance with: 1) permit and inspection requirements of the local jurisdiction; 2) applicable state and federal codes, standards and regulations; and 3) program Installation Standards and Policy and Procedures.

These Residential Contractor Program Installation Standards: 1) reference some, but not all, applicable codes and standards; 2) include additional measure-specific program criteria; and 3) contain graphics to illustrate some program requirements. This manual provides guidelines. When there is disparity between these standards and local codes, the more stringent requirement shall take precedence.

CHAPTER 3

DUCT INSTALLATION AND SEALING STANDARDS

APPROVED MATERIALS

1. ALL MATERIALS

- Surface burning characteristics, per UL 723, ASTM E84, *NFPA 255*, or *UL 2043*:
 - Flame spread rating not to exceed 25.
 - Smoke developed rating not to exceed 50.
- Only exterior-rated products shall be used on the exterior (outdoors).

2. DUCT MASTIC

- All Ducts
 - Mastic shall be:
 - Non-toxic and water resistant.
 - UL listed and labeled per UL 181A or 181B standards.
- Flexible Metallic and Nonmetallic Ducts
 - Mastic shall be:
 - UL labeled *to include the marking* “181B-M”.
 - Compatible with the duct to which it is applied.
- Rigid Metal Ducts and Components
 - Mastic shall be UL labeled “181A-M” or “181B-M”.
- Rigid Fiberglass Ducts
 - Mastic shall be labeled “181A-M”.

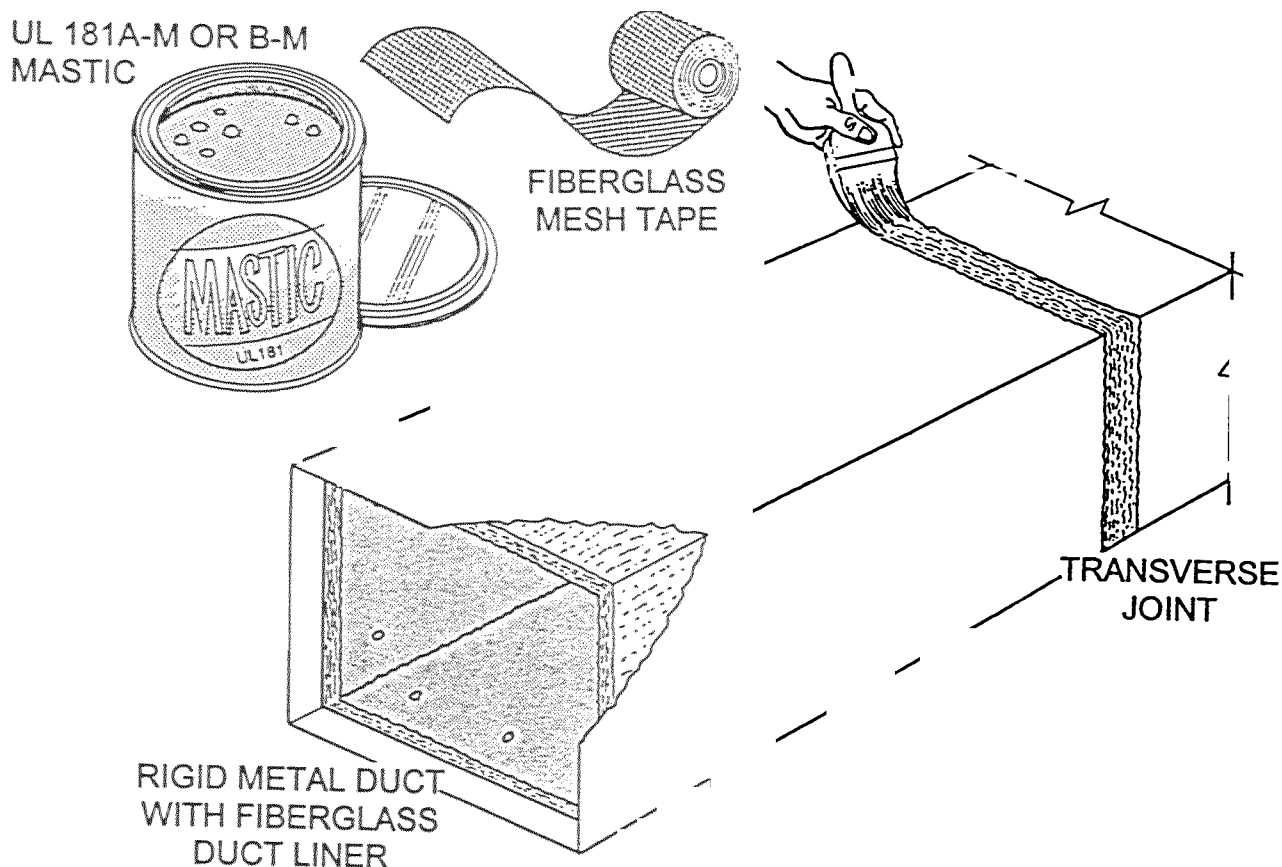
UL 181A APPLIES TO SEALANTS USED ON RIGID FIBERGLASS DUCT BOARD	PRESSURE SENSITIVE TAPE	MARKED “181A-P”
	HEAT ACTIVATED TAPE	MARKED “181A-H”
	MASTIC	LABELED “181A-M”
181B APPLIES TO SEALANTS USED ON <u>FLEXIBLE DUCTS</u>	PRESSURE SENSITIVE TAPE	MARKED “181B-FX”
	MASTIC	LABELED “181B-M”

3. MESH TAPE

- All Ducts
 - Mesh fabric used to reinforce duct mastic shall:
 - comply with mastic manufacturer's instructions, or
 - meet the following specifications:
 - Fiberglass mesh tape.
 - Weave per inch: 9 x 9 minimum.
 - Thickness: 0.006" minimum.
- Flexible Ducts and Rigid Metal Ducts
 - Mesh tape width: 2" minimum.
- Rigid Fiberglass Ducts
 - Mesh tape width: 3" minimum.

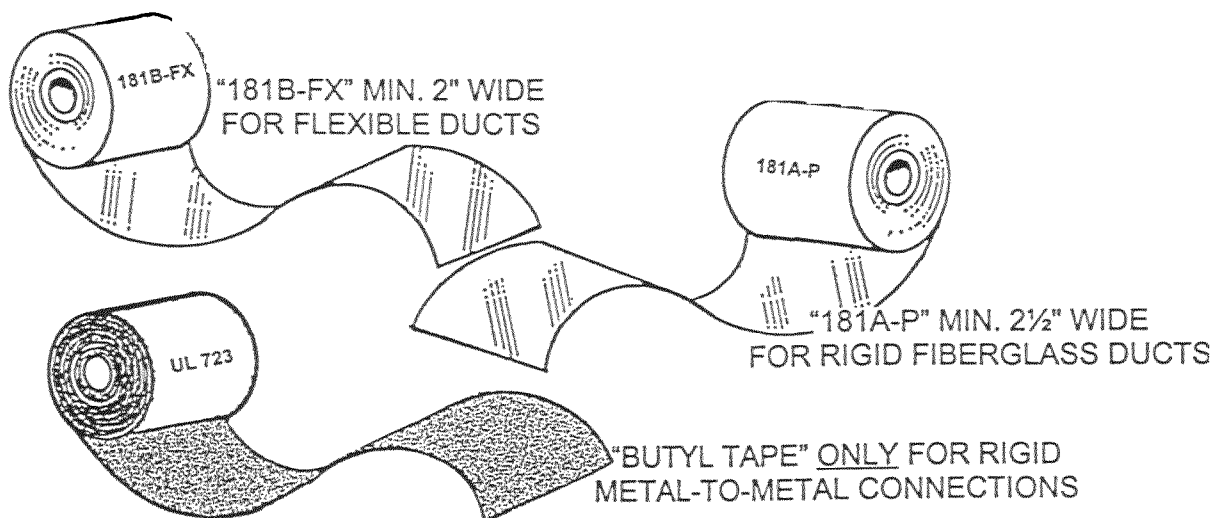
4. HEAT ACTIVATED TAPE

- Rigid Fiberglass Ducts (Only)
 - Tape shall be:
 - UL 181 listed and marked "181A-H".
 - 3" minimum width.



5. PRESSURE SENSITIVE TAPE

- All Ducts
 - Cloth-backed tapes are not allowed.
- Flexible Metallic and Nonmetallic Ducts
 - Tapes shall be UL 181B Listed and marked.
 - *Markings shall include "181B-FX".*
 - Tape width: 2" minimum.
- Rigid Metal Ducts and components
 - Tapes shall be UL 181 Listed and marked "181A-P" *and/or* "181B-FX".
 - Exception: *Metallic tape with butyl adhesive ("Butyl tape") without 181A or 181B markings may be used to seal rigid metal-to-metal connections.*
 - Butyl adhesive shall be at least 15 mils thick.
 - *Tape shall meet surface burning characteristics per Item 1.*
 - Tape width: 2" minimum.
- Rigid Fiberglass Ducts
 - Tape shall be UL 181A listed and marked "181A-P".
 - Tape width: 2-1/2" minimum.
- Access Panels
 - Pressure sensitive metallic tape with non-butyl adhesive.
- High Temperature Applications
 - Pressure sensitive metallic tape with non-butyl adhesive and service temperature rating of at least 265°F.

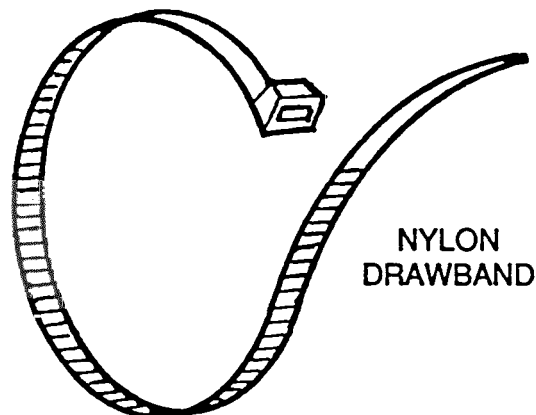
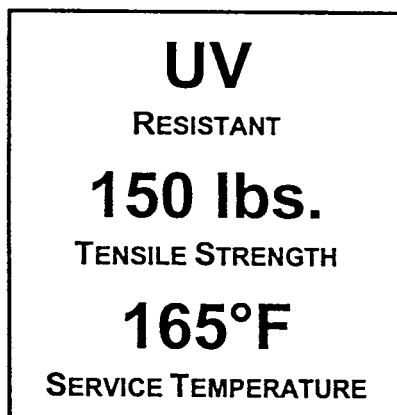


6. AEROSOL-APPLIED SEALANT SYSTEMS

- All Ducts
 - An approved* aerosol-applied sealant system shall be used, which meets the requirements of CEC Title 24, Residential Manual, Chapter 2, Section 150(m).
 - Aerosol-applied sealants utilized shall:
 - be non-toxic.
 - be *in compliance with* Item 1.
 - meet all performance standards established by the manufacturer of the aerosol sealing equipment.
 - have passed 50,000-heating-cycle accelerated testing for seal longevity (e.g., air temperature swings between 70°F and 200°F, and pressure differential swings between 0 Pa and 150 Pa).

7 DRAWBANDS

- All Ducts
 - Drawbands shall:
 - comply with duct manufacturer's installation instructions.
 - conform to the following specifications:
 - Weather- and UV-resistant duct ties or stainless steel worm drive clamps.
 - Loop tensile strength: 150 pounds minimum.
 - Service temperature rating: 165°F minimum.



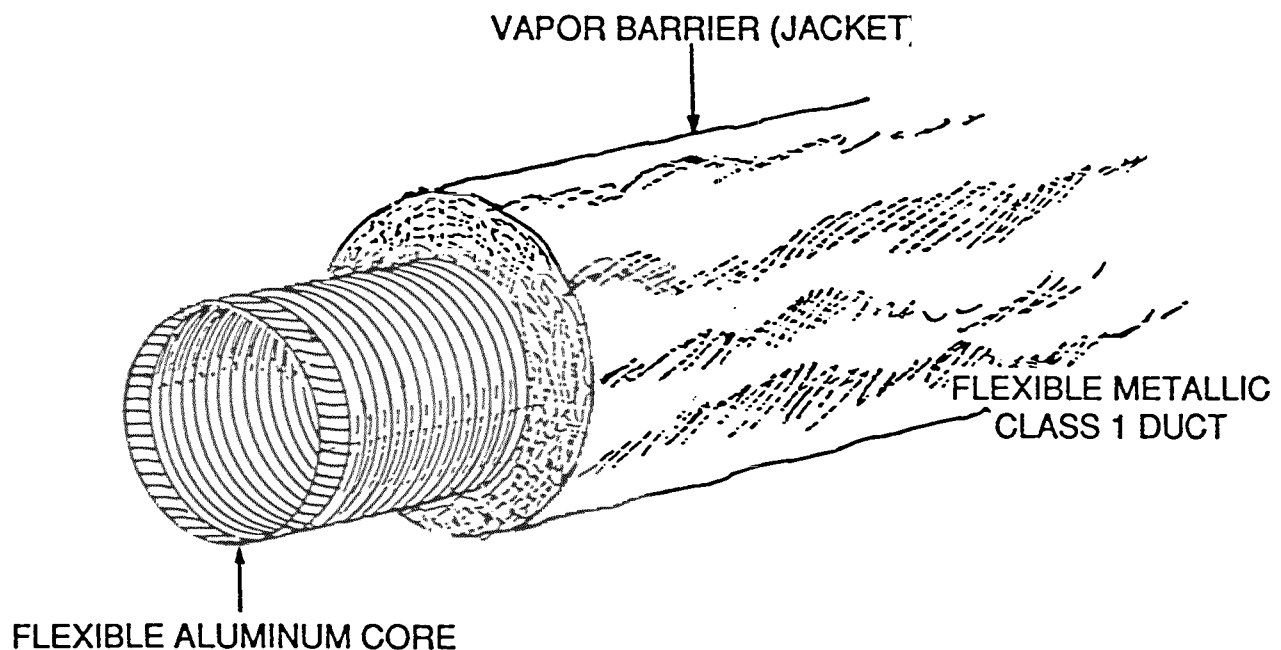
*Example: Aerosol system bearing U.S. Patent No. 5,522,930, Method and Device for Producing and Delivering an Aerosol for Remote Sealing and Coating.

8. ALL FLEXIBLE DUCTS

- Ducts shall conform to NFPA 90B and UL 181 Class 1.
- Nonmetallic insulated ducts with air-permeable core not allowed.
- Insulation shall have minimum thermal resistance of R-4.2, or *greater if required by local code*.
- Vapor barrier:
 - Thickness: 2.5 mils minimum.
 - Permeance: 1.0 perm maximum.
 - *UV degradation-resistant material* recommended.

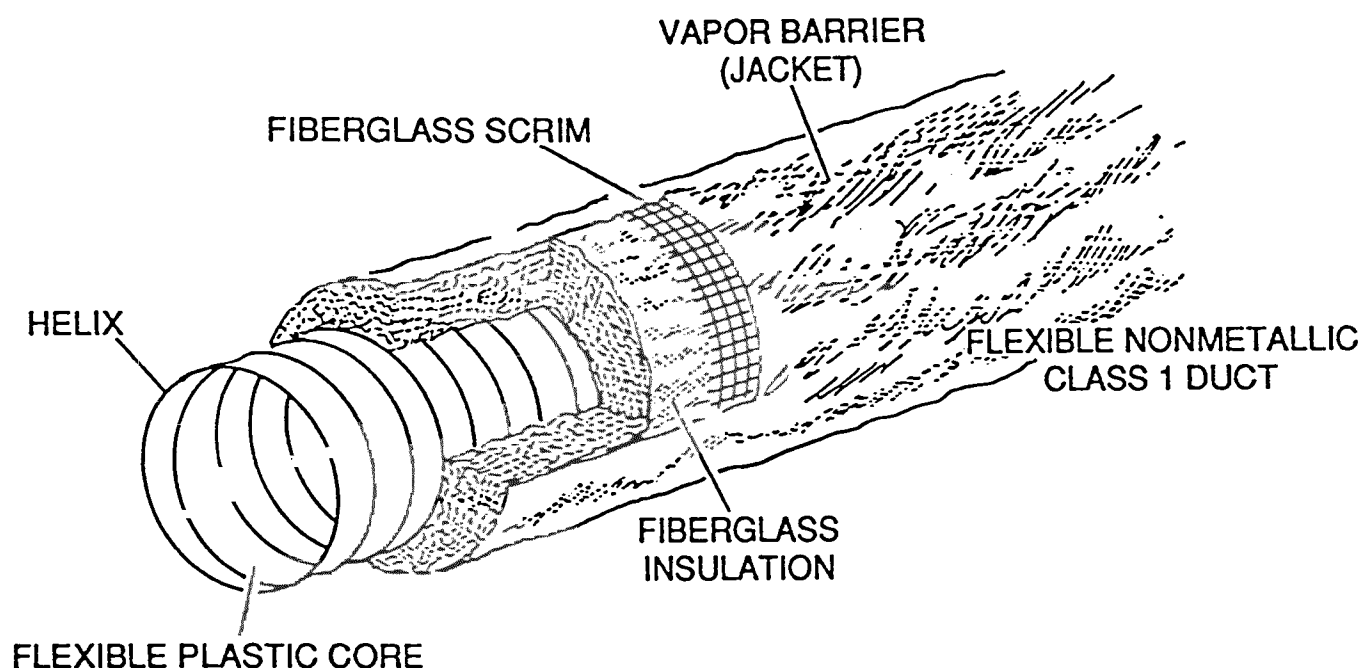
9. FLEXIBLE METALLIC DUCTS

- Ducts shall be rated to withstand the designated pressures and velocity of the system, but not less than:
 - 2 inches of water column (IWC) (500 Pa) positive pressure,
 - 0.75 IWC (188 Pa) negative pressure, and
 - 2500 fpm velocity.
- Core shall be fabricated from minimum 0.0065" thick aluminum material or equivalent.



10. FLEXIBLE NONMETALLIC DUCTS

- Ducts shall be rated to withstand the designated pressures and velocity of the system, but not less than:
 - 2 IWC (500 Pa) positive pressure,
 - 0.75 IWC (188 Pa) negative pressure, and
 - 2000 fpm velocity.
- Duct Core (“Inner Liner”)
 - Core shall be fabricated with a spring steel helix bonded within a nonporous material (e.g., molded composite or 2-ply lamination of polyester).
 - Air-permeable core not allowed.



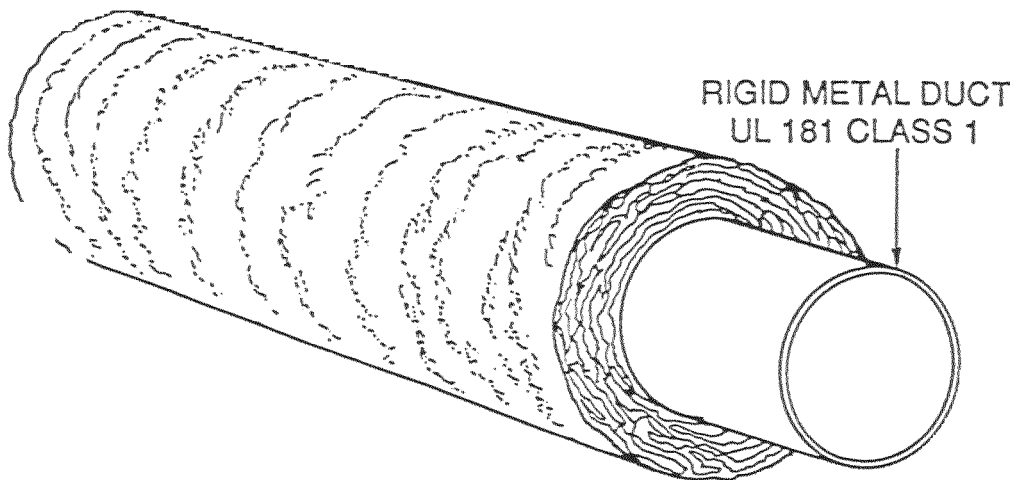
11. RIGID FIBERGLASS DUCTS

- Shall conform to NFPA 90B and UL 181 Class 1.
- Shall be constructed of high-density fiberglass duct board

12. RIGID METAL DUCTS

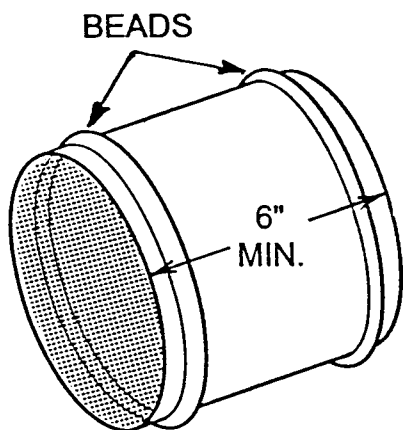
- Shall conform to NFPA 90B and UL 181 Class 1 or Class 0.
- Shall be constructed of noncorrosive material.
- Rectangular metal ducts shall conform to UMC requirements.
- Round metal ducts shall conform to minimum thickness requirements of the UMC, some of which are shown in the table below.

ROUND METAL DUCTS At Positive Static Pressure up to 2 IWG (500 Pa)		
DIAMETER of Duct	MIN. SHEET GAGE (Galvanized Steel)	MIN. B. & S. GAGE (Aluminum)
Up to 14"	26	24
15" to 23"	24	22
24" to 37"	22	20
38" to 51"	20	18

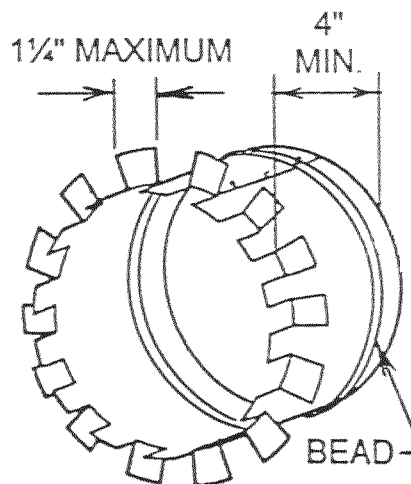


13. SHEET METAL

- All Rigid Components
 - Components shall be constructed of noncorrosive materials.
 - Fittings (starting collars, splicing sleeves/couplings, adjustable elbows, wyes, etc.) shall have wall thickness (gage) no thinner than specified for attached ducts (see Item 12 above).
- Minimum Requirements for Fittings Used with Flexible Nonmetallic Ducts
 - Starting Collars
 - 4" installed length (6" recommended).
 - 26 gage galvanized steel up to 14" diameter.
 - Splicing Sleeves
 - 6" length (8" recommended).
 - 26 gage galvanized steel up to 14" diameter.
 - All Fittings
 - Fittings shall be beaded at each core connection (e.g., both ends of a sleeve) when flexible nonmetallic ducts are attached.
 - *Exception:* When a preexisting fitting is not beaded, the core's wire coil shall be secured to the fitting as prescribed in Item 30.



DOUBLE-BEADED SLEEVE MIN. 6" LONG
FOR FLEXIBLE NONMETALLIC DUCTS

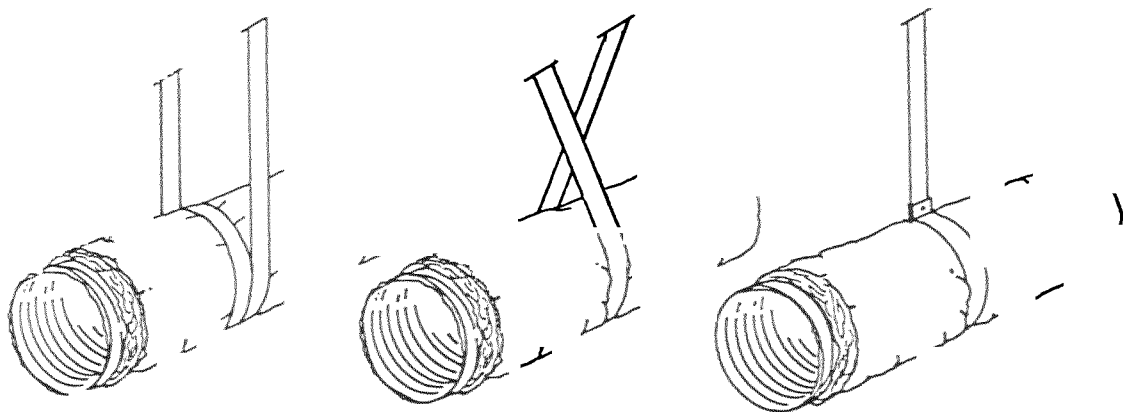


SHEET METAL COLLAR (DOVETAIL)
MIN. 4" LONG AND BEADED FOR
FLEXIBLE NONMETALLIC DUCTS

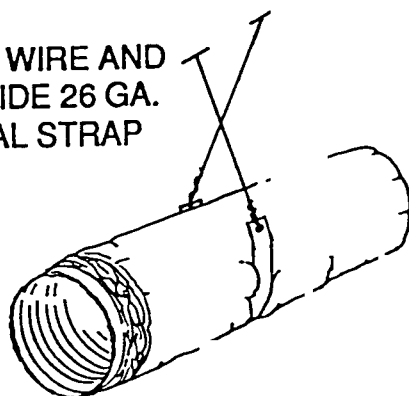
14. DUCT SUPPORTS

- All Ducts
 - Support materials shall be corrosion resistant and shall:
 - conform to duct manufacturer's installation instructions.
 - be installed in compliance with Item 21.
- Flexible Ducts (Horizontal and Vertical)
 - Nonmetallic Support Straps
 - *May be used only if allowed by the local jurisdiction.*
 - *Polypropylene monofilament, woven polyester, polyester scrim reinforced vinyl laminate, or equivalent.*
 - *Minimum width: 1-3/4".*
 - *Minimum tensile strength: 70 lbs./inch of width.*
 - Sheet Metal Support Straps and Saddles
 - Width: 1-1/2" minimum.
 - Thickness: 26 gage minimum.
 - Support Saddles
 - Shall fit neatly around and cover lower half (180°) of duct.
 - Shall not constrict inner diameter of duct nor cut the jacket.

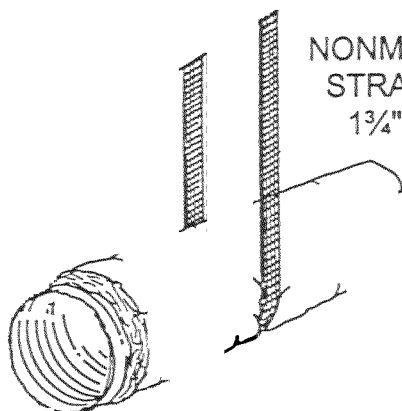
26 GA. SHEET METAL STRAP, MIN. 1½" WIDE



18 GA. WIRE AND
1½" WIDE 26 GA.
METAL STRAP



NONMETALLIC
STRAP, MIN.
1¾" WIDE



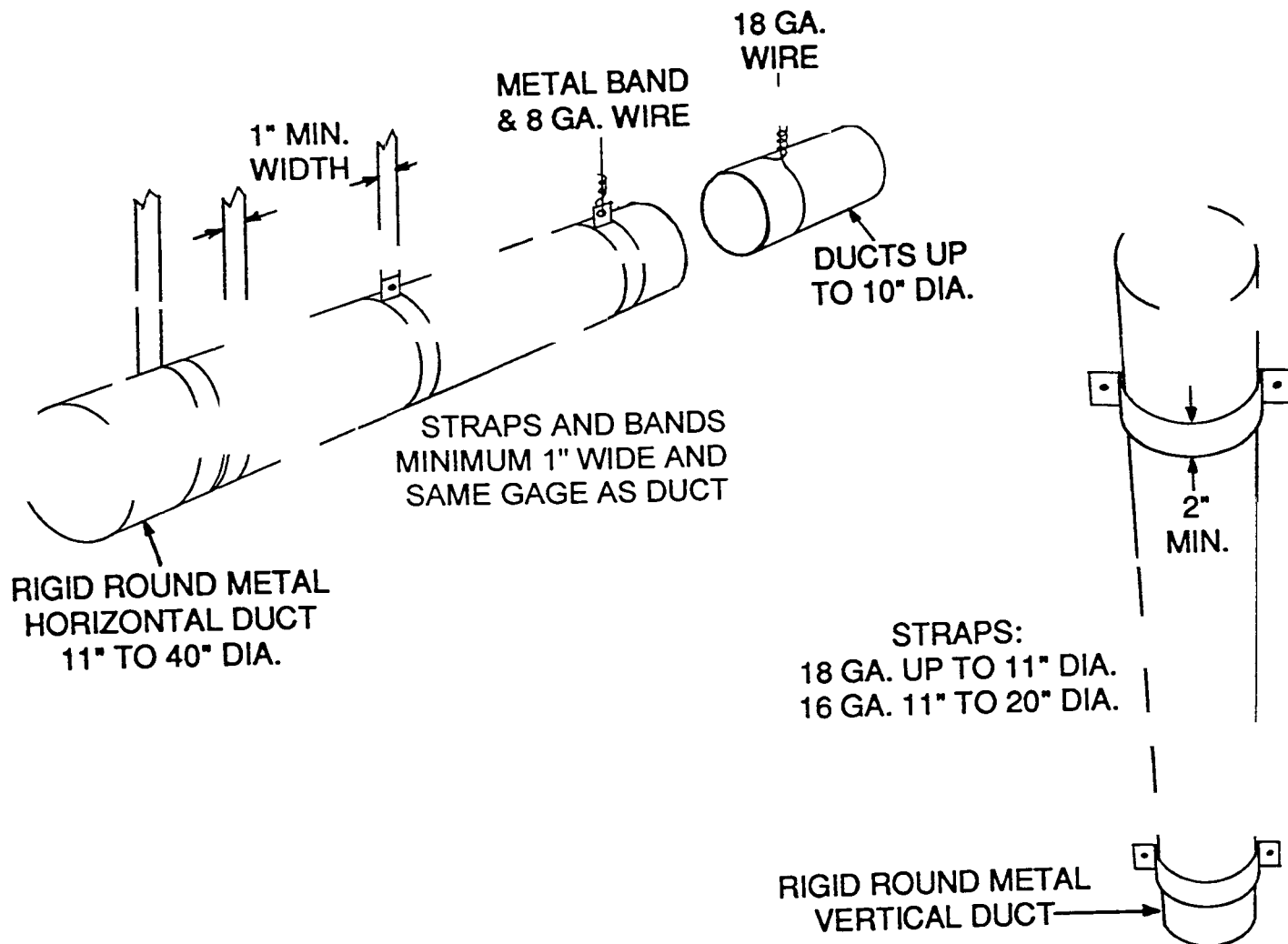
DUCT SUPPORTS (continued)

Horizontal Rigid Round Metal Ducts

- Up to 10" Diameter
 - Galvanized steel straps, same gage as duct, 1" minimum width or
 - 18 gage galvanized steel wire.
- 11" to 40" Diameter
 - Galvanized steel straps, same gage as duct, 1" minimum width or
 - 8 gage galvanized steel wire tied to a galvanized steel band, 1" minimum width, surrounding the duct.

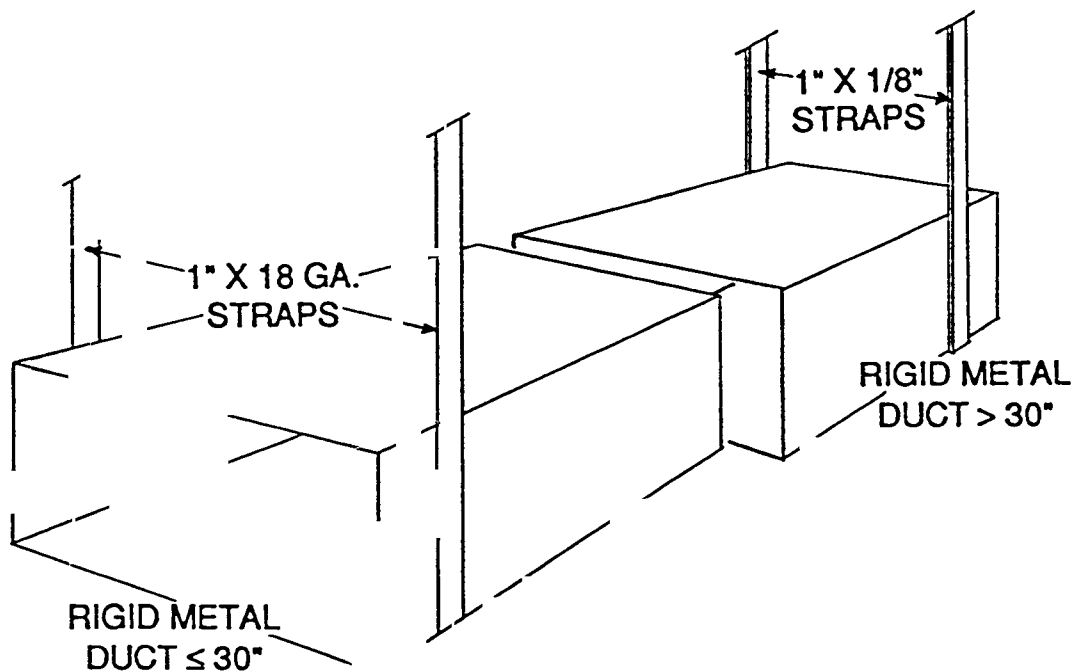
Vertical Rigid Round Metal Ducts

- Up to 10" Diameter
 - 18 gage galvanized steel straps, 2" minimum width.
- 11" to 20" Diameter
 - 16 gage galvanized steel straps, 2" minimum width.



14. DUCT SUPPORTS (continued)

- Horizontal Rigid Rectangular Metal Ducts
 - Maximum Side of Duct 30"
 - 1" x 18 gage strap
 - Maximum Side of Duct Over 30"
 - 1" x 1/8" strap
- Vertical Rigid Rectangular Metal Ducts
 - Maximum Side of Duct 24"
 - 1" x 1/8" strap
 - Maximum Side of Duct 36"
 - 1" x 1" x 1/8" angle bracket
- Rigid Fiberglass Ducts
 - Supports shall be in conformance with local codes.

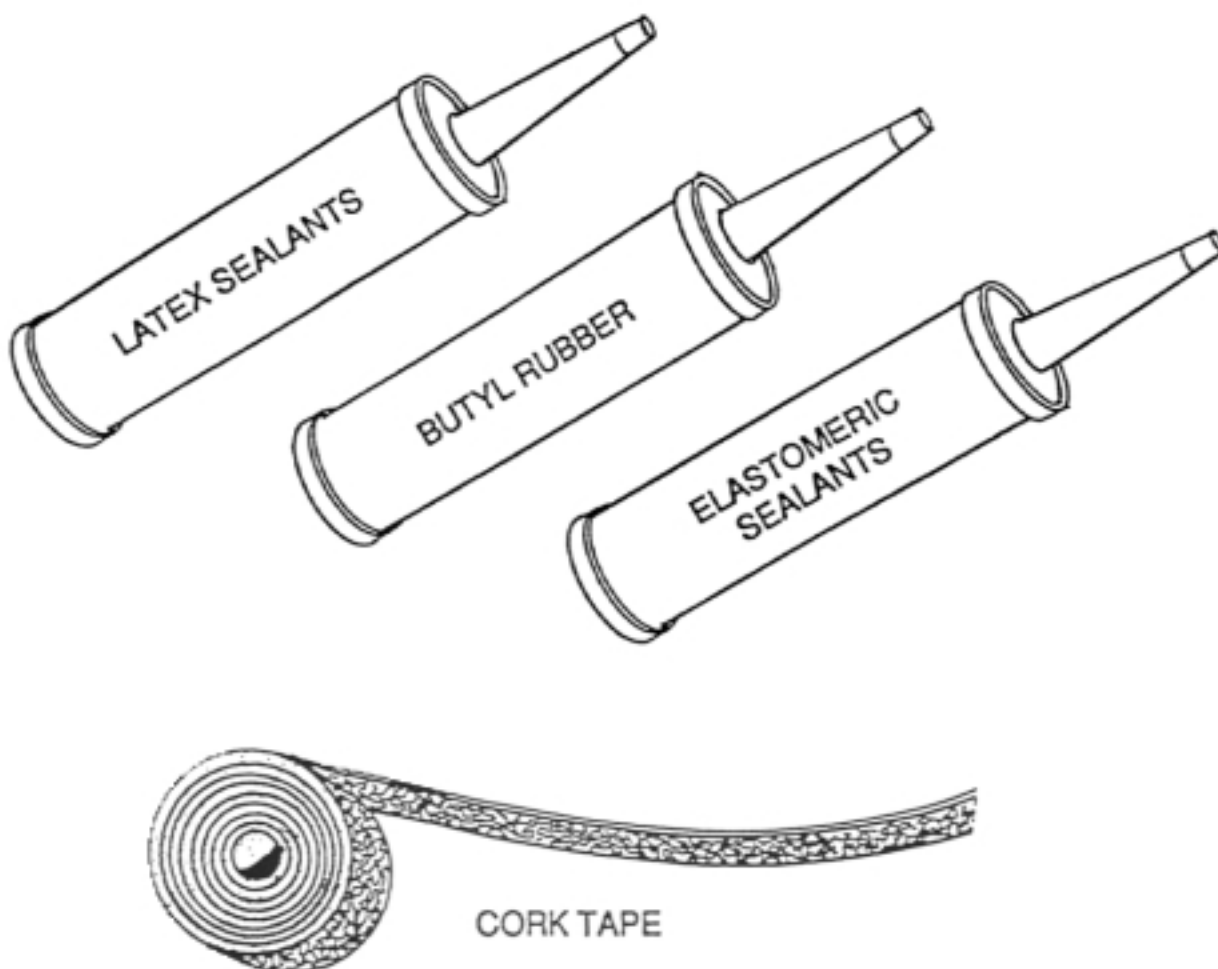


15. CAULKING MATERIALS

- All Materials
 - Shall be non-toxic.
- Latex Sealing Compounds
 - Shall be in conformance with ASTM C834.
- Butyl Rubber Sealants
 - Shall be in conformance with F.S. A-A-272A
- Elastomeric Joint Sealants (Including Polysulfide, Polyurethane, and Silicone)
 - Shall be in conformance with ASTM C920 or F.S. A-A-1556A.

16. CORK TAPE

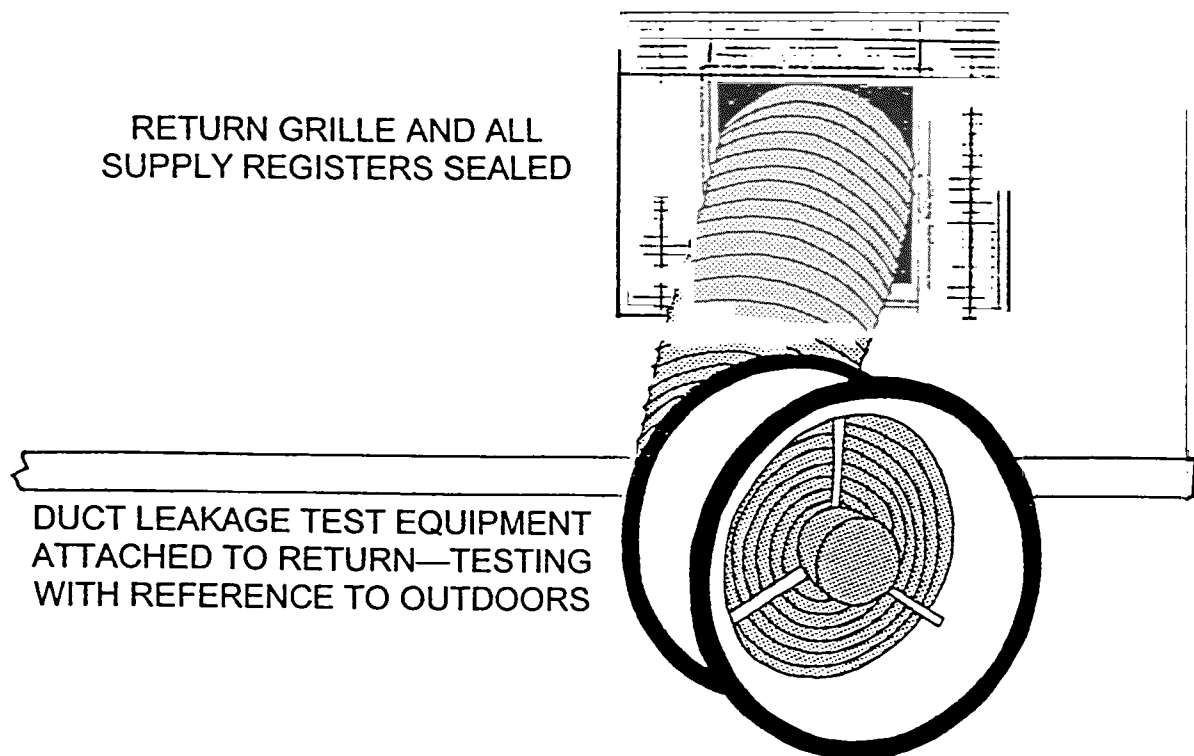
- Shall be non-toxic.
- Shall be non-corrosive to copper.
- Elongation: 200% minimum.
- Hardening: 37% maximum.



INSTALLATION AND PERFORMANCE CRITERIA

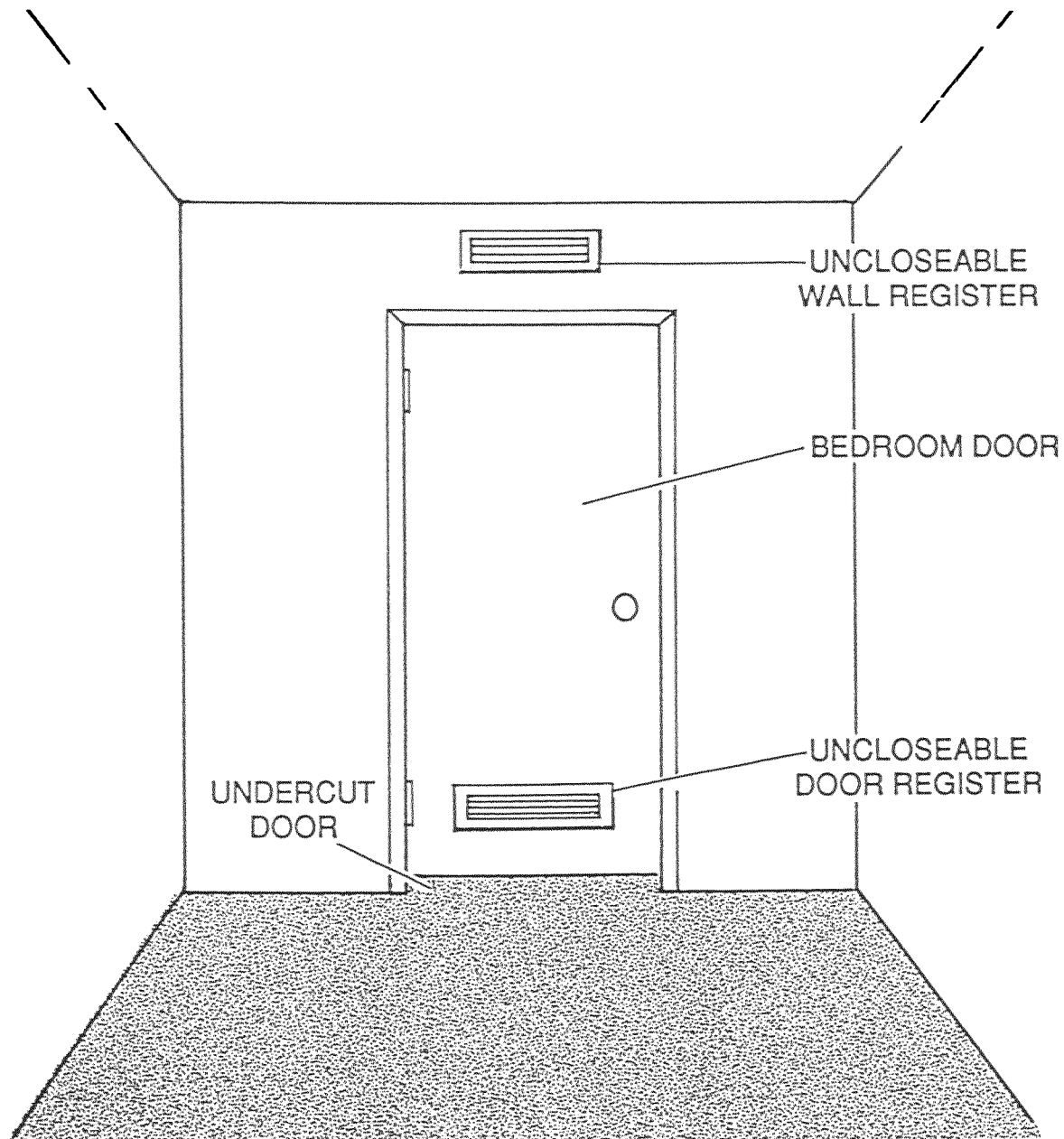
17. DUCT SYSTEM DESIGN AND PERFORMANCE

- New Duct System Design
 - Supply and return plenums, ducts and registers shall be designed/selected in accordance with standard practices set forth by ACCA.
 - Air flow and static pressure shall be as specified by HVAC manufacturer.
- Duct System Airflow
 - After duct system repair, installation and sealing is complete, airflow through the system shall not be less than required by manufacturer.
 - If too low, corrective steps shall be taken.
- Combustion Appliance Safety (CAS) Testing prescribed in the Program Policy & Procedures shall be conducted in accordance with Chapter 4:
 - Before performing Duct Installation and Sealing.
 - After completing Duct Installation and Sealing.



17. SYSTEM DESIGN AND PERFORMANCE (continued)

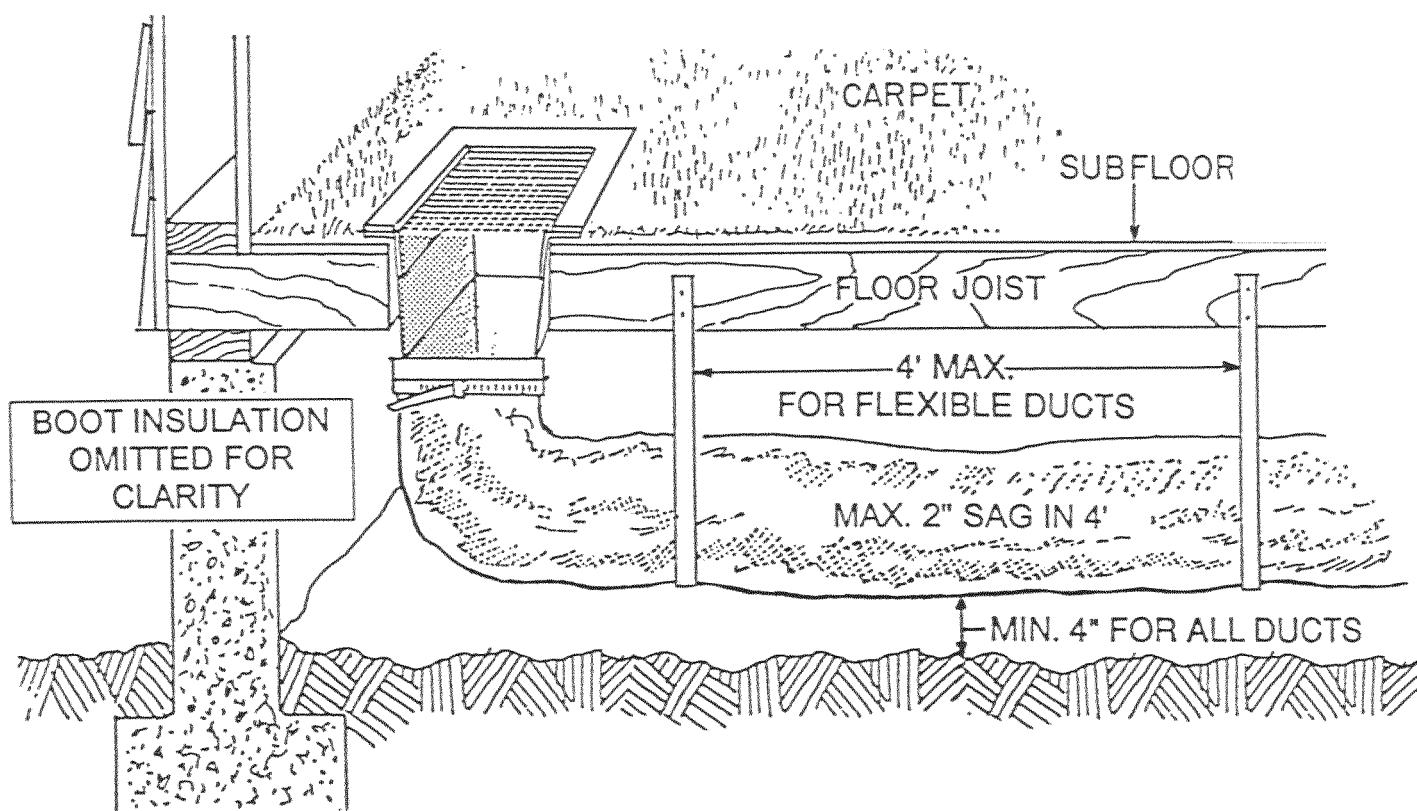
- Duct System Balance
 - Duct systems shall be balanced to provide adequate air movement throughout the living space with interior doors closed.
 - Rooms closed off by doors from the FAU return intake shall be provided with an adequate return air path.
 - The required return air path for each room shall be provided by a permanent means, such as one of the following:
 - A transfer or jump duct from the room to the hallway.
 - Uncloseable grilled or louvered venting in the door or wall.
 - An undercut door leading to the hallway.



18 GENERAL INSTALLATION CRITERIA

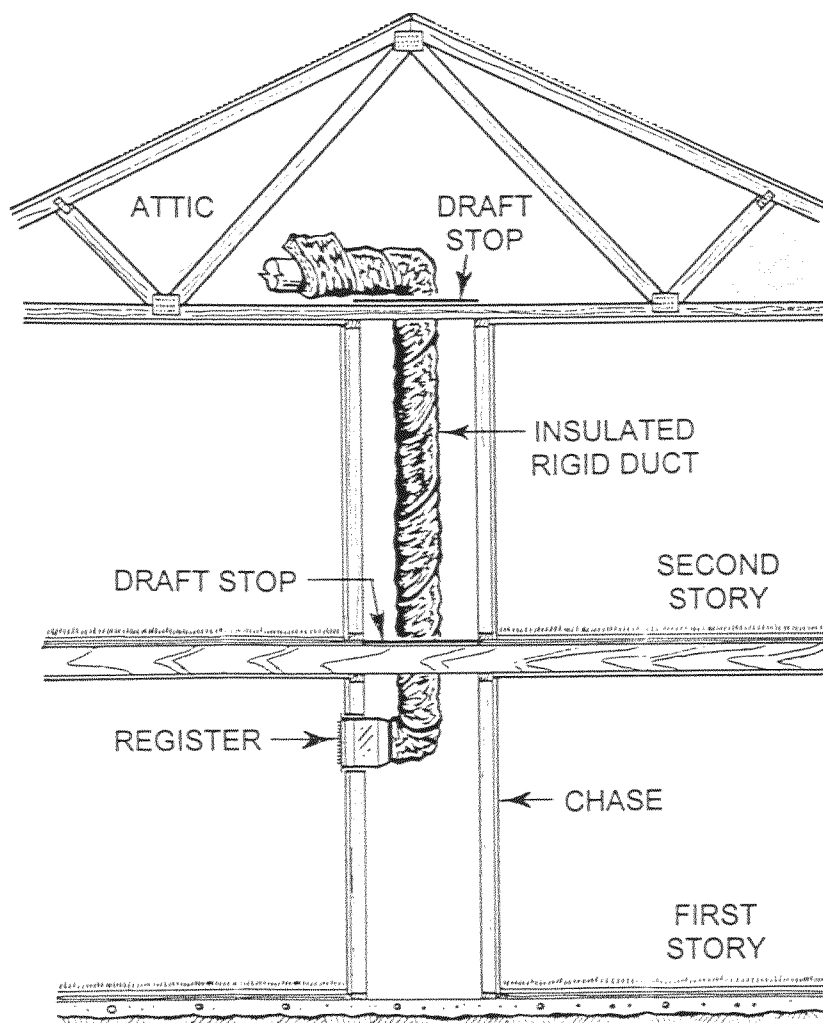
- All Duct Installations

- Installation shall comply with these standards, manufacturer's instructions and local codes, with the more stringent requirements taking precedence.
- Ducts shall be:
 - installed with at least 4" of separation from earth.
 - protected from physical damage.
 - installed in locations not exposed to the weather, unless designed for exterior use.
 - supported as prescribed in Item 21.
- Ducts installed within a closet or room shall be enclosed within a cavity constructed of materials equivalent to those used in construction of the closet/room.
- A building cavity shall not be used as a duct without a sealed duct board or metal liner.
- Existing platform returns shall be sealed per Item 34.
- Existing crawl space plenums shall be abandoned per Item 35.



18 GENERAL INSTALLATION CRITERIA (continued)

- Vertical Duct Installations
 - Rigid metal duct strongly recommended.
 - Flexible Ducts
 - Maximum vertical duct length shall be per manufacturer's instructions or 15', whichever is less.
 - Supports shall be installed at intervals not exceeding 6'.
 - Flexible ducts shall not be used for vertical risers in duct systems serving more than two stories. Such ducts shall not penetrate construction where fire dampers are required.
- Ducts Concealed in a Chase
 - Draft stops shall be installed (per UBC Section 708):
 - at every floor level, and
 - between the top story and the roof or attic space.
 - Draft stops shall be noncombustible (e.g., 24 gauge sheet metal collar).

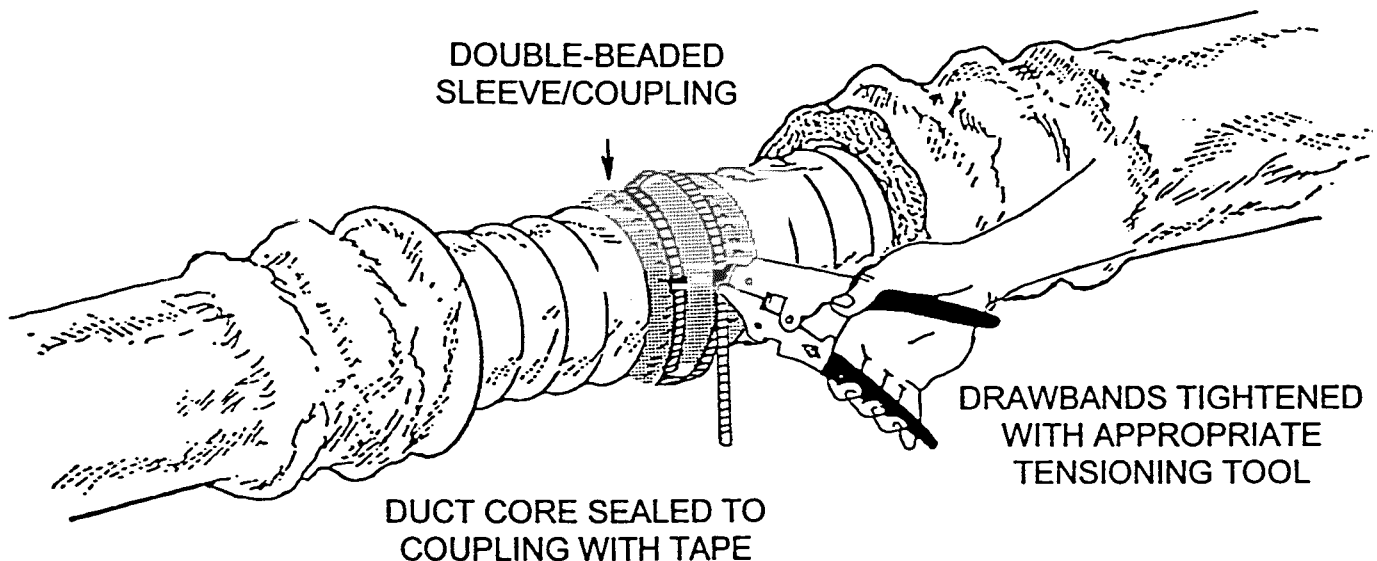


18. GENERAL INSTALLATION CRITERIA (continued)

- Surface Preparation
 - Preparation shall be in conformance with duct and sealant manufacturers' instructions.
 - Surfaces shall be:
 - cleaned prior to application of tapes and sealants.
 - free of dust, dirt, oil, grease, moisture and similar substances.
- Air Handler Operation
 - Air handler shall:
 - be off during the application of all tapes and sealants.
 - remain off for the drying time specified by sealant manufacturer.

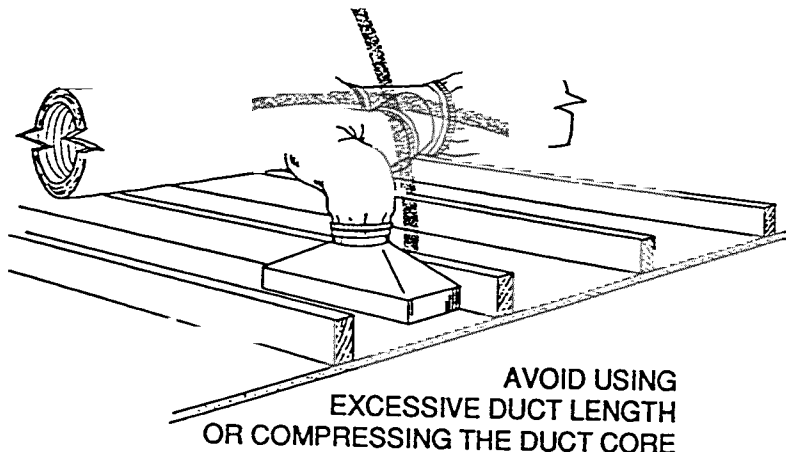
19. DRAWBAND INSTALLATION

- All Ducts
 - Drawbands shall be:
 - weather- and UV-resistant duct ties or stainless steel worm drive clamps (see Item 7).
 - installed per manufacturer's instructions and tightened appropriately with an adjustable tensioning tool.

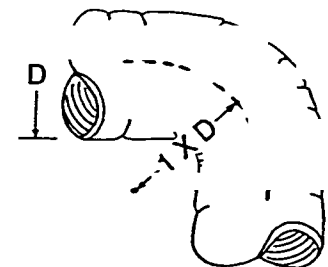


20. FLEXIBLE DUCT PRECAUTIONS

- Temperature Limit
 - Air flowing through flexible ducts shall not exceed 250°F.
 - Minimum distance from FAU to nonmetallic flexible duct shall be as specified by manufacturer or local code, whichever is greater.
- Harmful Exposure
 - Flexible ducts shall be installed to avoid exposure to:
 - sunlight (e.g., near turbine vents, windows, etc.).
 - sources of heat which exceed duct temperature limit.
 - other conditions that cause damage and/or degradation.
- Configuration
 - Ducts shall be installed:
 - fully extended, not compressed.
 - using minimum length required to make connections (e.g., run from trunk to register boot no longer than necessary).
 - in a manner which prevents:
 - dislocation, damage, or constriction of inside diameter.
 - incidental contact with metal fixtures, pipes or conduits.
- Duct Bends
 - Bends shall not be made across sharp corners or in any manner which restricts airflow.
 - Angle of bend shall not exceed 90 degrees.
 - Radius of the bend (measured from the center point of arc to centerline of duct) shall equal at least one duct diameter.



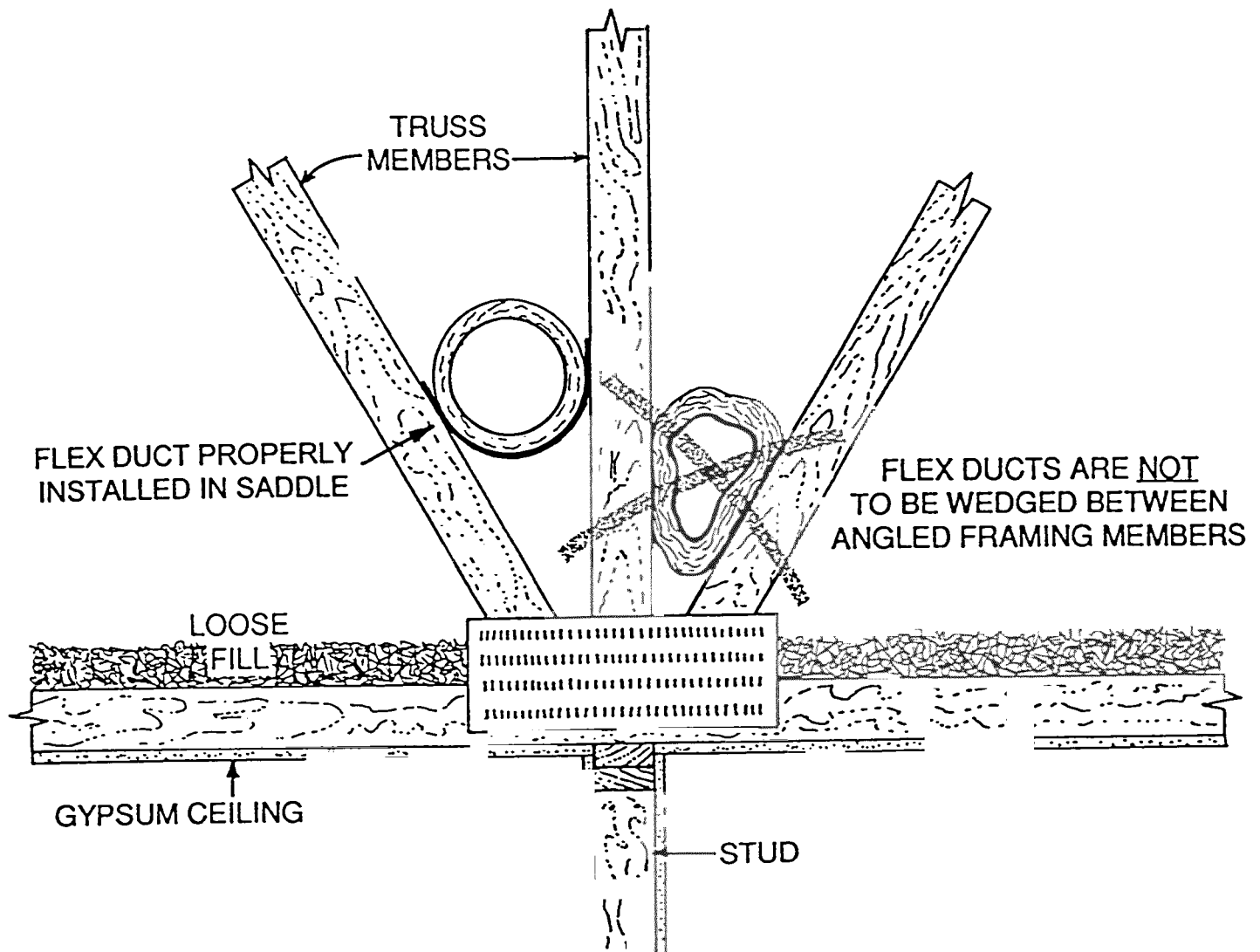
1 X D = MIN. RADIUS
OF ARC FORMED AT
CENTER LINE OF DUCT



Duct Installation Standards
(Installation Criteria)

21 DUCT SUPPORT INSTALLATION

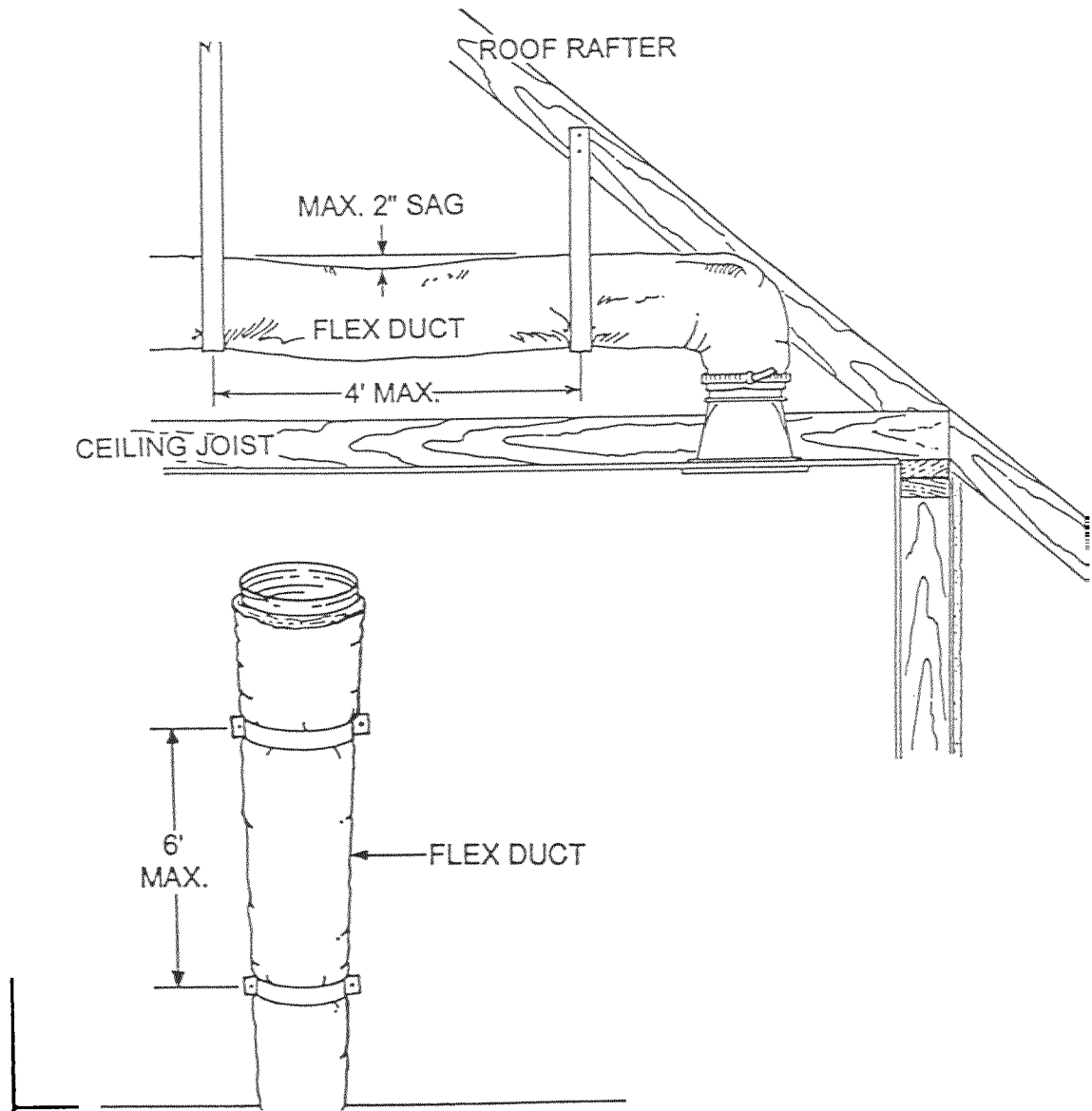
- All Ducts
 - Supports shall comply with duct manufacturer's instructions and local codes.
- Flexible Ducts
 - All Installations
 - Straps and other means of support shall not constrict the duct below its rated internal diameter.
 - Duct may rest on ceiling joists or truss members, if:
 - support spacing and sag limitations are met.
 - duct is not wedged between truss members.
 - Termination devices (e.g., register boots) shall be properly secured and shall not rely upon duct for support.



21. DUCT SUPPORT INSTALLATION (continued)

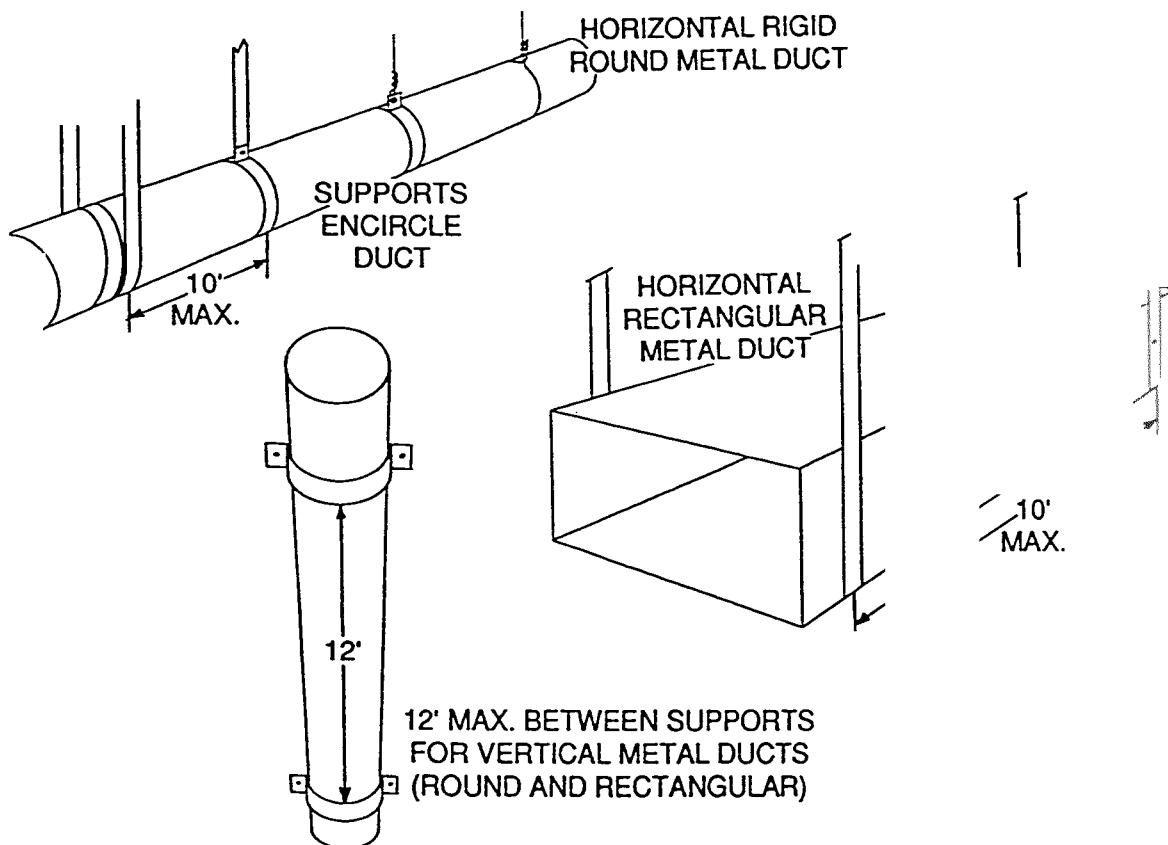
- Flexible Ducts (continued)

- *Nonmetallic Support Straps (When Allowed by Local Jurisdiction)*
 - *At each end, at least 2" shall be folded over and secured by two or more anchors that penetrate both layers of strap material.*
- Horizontal Flexible Ducts
 - Spacing between supports shall be 4' maximum.
 - Sag shall be no more than:
 - 1/2" per foot of distance between supports.
 - 2" between supports.
- Vertical Flexible Ducts
 - Spacing between supports shall be 6' maximum.



21. DUCT SUPPORT INSTALLATION (continued)

- Rigid Round Metal Ducts
 - Horizontal Installations
 - Spacing between supports shall be 10' maximum.
 - Support shall tightly encircle the duct.
 - Vertical Installations
 - Spacing between supports shall be 12' maximum.
- Rigid Rectangular Metal Ducts
 - Horizontal Installations
 - Spacing between supports shall be 10' maximum.
 - Support straps shall be secured to sides of duct with sheet metal screws, rivets or bolts.
 - Vertical Installations
 - Spacing between supports shall be 12' maximum.
- Rigid Fiberglass Ducts
 - Ducts shall be supported and reinforced in conformance with *the UMC and local code*.
- Horizontal Plenums (Metal and Fiberglass Duct Board)
 - Shall not rely on furnace for support.
 - Shall be independently supported at each end, and intermediately if over 10' in length.

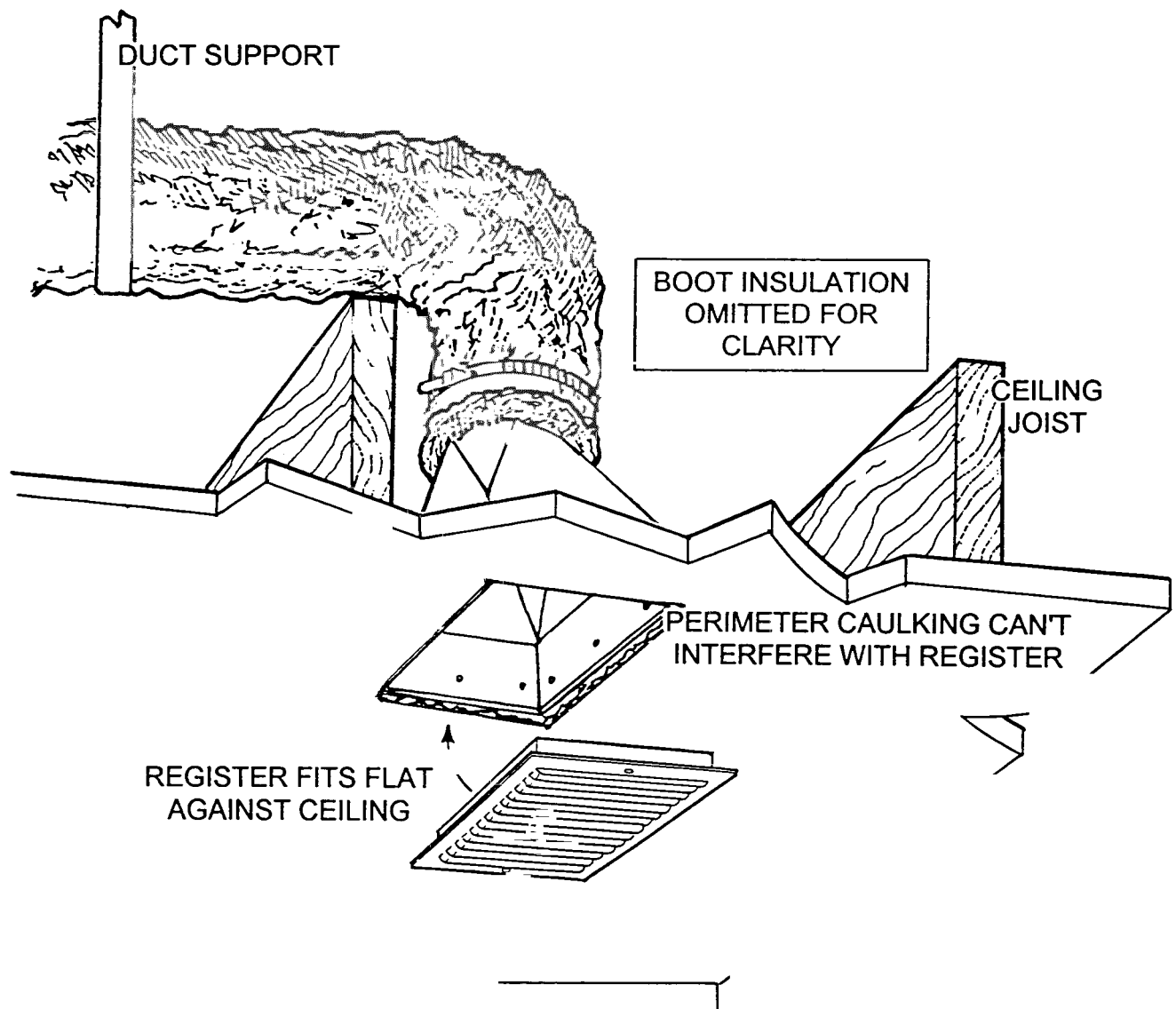


22. REGISTER GRILLES

- All Units
 - The entire perimeter of the register shall be in contact with the mounting surface (ceiling, floor, wall).
 - Sealant applied to perimeter of the register boot shall not interfere with removal and replacement of the register.
 - Damaged and defective registers should be replaced.

23. EXPOSED DUCTS

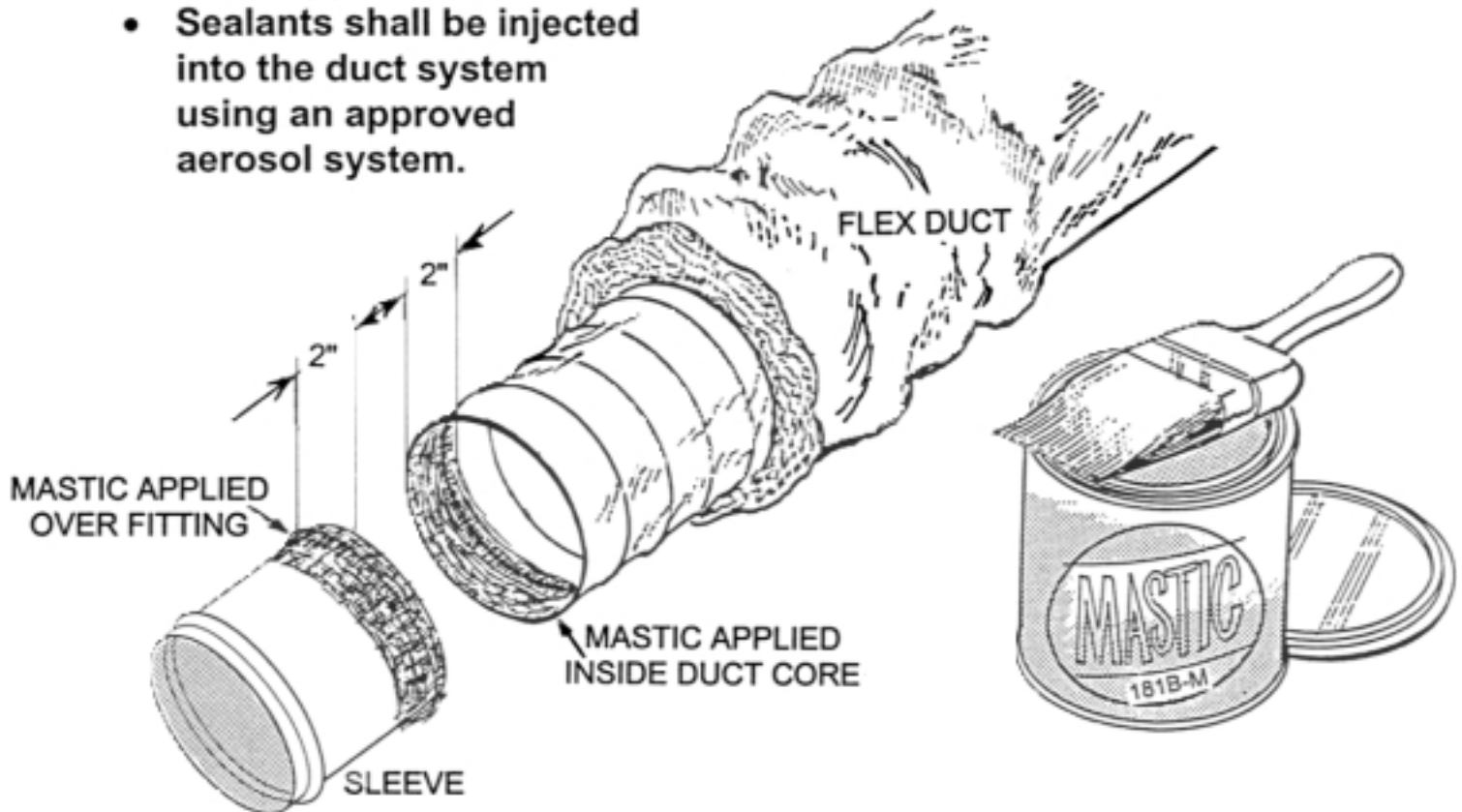
- Rigid metal ducts shall be used:
 - in areas subject to human contact.
 - under floors without foundation walls.
 - in exterior locations.



SEALING REQUIREMENTS

24. CLOSURE SYSTEMS

- All Closure Systems
 - A complete, durable seal shall be achieved.
 - Joints and seams shall be mechanically secured in conformance with these standards and the UMC.
- Externally-Applied Closure Systems
 - Sealing materials shall be centered over the joint or gap and shall extend at least 1" onto each of the two joined/sealed surfaces.
 - Sealing materials may be:
 - Duct mastic alone (gaps up to 1/8"), or a mastic-plus-mesh combination (gaps over 1/8").
 - Pressure sensitive tape alone (gaps up to 1/4"), or a tape-plus-mastic combination (gaps over 1/4").
- Internally-Placed Mastic Sealant (Core-to-Fitting Joints)
 - Mastic may be applied either:
 - inside the duct core, or
 - onto the rigid component over which the core is attached.
 - Mastic coating shall be at least 1/8" thick and 2" wide.
- Aerosol-Applied Sealants
 - Sealants shall be injected into the duct system using an approved aerosol system.



24. CLOSURE SYSTEMS (continued)

- **Factory Fabricated Sections**
 - All factory installed closure systems shall be fabricated to meet the requirements of UL 181 standards under the Factory Follow-Up Service Program.
 - Compliance shall be verifiable by:
 - visible markings on the joint, or
 - manufacturer's written certification.
- **Field Fabricated Sections**
 - Tapes shall be marked, and mastic containers shall be labeled, in conformance with:
 - UL 181A for rigid fiberglass ducts.
 - UL 181B for flexible metallic and nonmetallic ducts.
 - UL 181A or 181B for rigid metal ducts and components.
 - *Exception: Butyl tape without UL 181 markings may be used to seal metal-to-metal connections, per Item 5.*

